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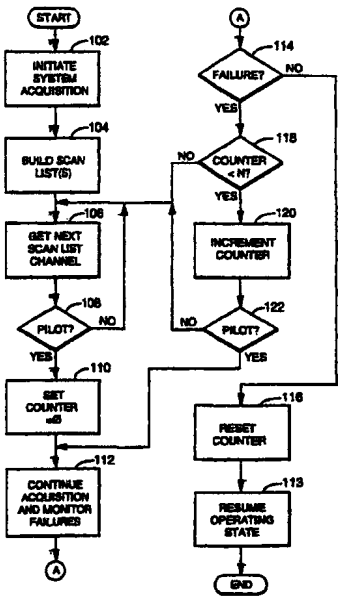
(54) Title: WIRELESS COMMUNICATION FRINGE COVERAGE ENHANCEMENT




(57) Abstract: A CDMA wireless mobile unit (10) is configured to monitor system access failures (114) as the unit (10) attempts to establish and maintain contact while operating in a base station fringe coverage area. The unit (10) counts the number of access failures (118) associated with a particular system identification selected from a preferred roaming list (104). After a specified number of failures, the mobile unit (10) selects a new system identification (106) from the preferred roaming list (104).

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# WIRELESS COMMUNICATION FRINGE COVERAGE ENHANCEMENT

## Field of Invention

The invention relates to wireless communications systems, and in particular to mobile unit operations during fixed communication system acquisition.

## Background

FIG. 1 is a block diagram showing a typical mobile communications unit 10, and base stations 12, 14, and 16. Base station 12 is connected to Mobile Switching Center (MSC) 18, base station 14 is connected to MSC 20, and base station 16 is connected to MSC 22.

Mobile unit 10 comprises processor 24, program memory 26, and data memory 28. Also connected to mobile unit 10 are antenna 30, user interface 32, and display 34. Interface 32, such as a conventional keypad, allows a user to input information to mobile unit 10. Display 34 displays information to a user with, for example, a conventional liquid crystal display.

Mobile unit 10 typically contains circuits for storing and manipulating electrical information. Such electronic circuitry may be contained in, for example, an integrated circuit microprocessor, or may be contained in an application specific integrated circuit (ASIC). Processor 24 may comprise a central processing unit, a clock, read-only-memory (ROM) 25, and other circuits necessary for hardware control. In some mobile unit 10 configurations, processor 24 follows coded instructions stored in ROM 25 and in non-volatile program memory 26, and uses information stored in data memory 28, to control communication operations. An example of one such operation is acquiring a fixed communications system, as described below.

The Telecommunications Industry Association / Electronics Industry Association Interim Standard 683A (TIA/EIA/IS-683A), incorporated herein by reference in its entirety, provides for a Preferred Roaming List (PRL) for Code Division Multiple Access (CDMA) mobile communications systems such as cellular telephones. Commercial carriers have assigned unique system identification numbers (SIDs) to fixed communication equipment, typically base stations such as base stations 12, 14, and 16. However, SIDs may be assigned to other communication system components such as MSCs 18, 20, and 22. By agreement between commercial carriers, a particular SID or group of SIDs may be considered "preferred" as a mobile unit roams outside the geographic coverage area of the subscriber's commercial carrier.

A mobile unit's system acquisition function uses information contained in the PRL to determine the order of CDMA channels or analog frequencies to access when the mobile unit must acquire a system. A mobile unit may have to acquire a channel or frequency during, for example, initial power-on or when a current channel or frequency is lost for many possible reasons.

TABLE I - Acquisition Records

| # | Acq Type | A/B | Pri/Sec | Blocks/Chans |
|---|---|---|---|---|
| 0 | PCS CDMA Blocks | -- | -- | B |
| 1 | PCS CDMA Blocks | -- | -- | A |
| 2 | PCS CDMA Channels | -- | -- | 283 699 384 777 |
| 3 | Cellular Analog | System A | -- | -- |

TABLE II - System Records

| # | SID | NID | Neg/Pref | Geo | Priority | AcqIndex | Roam Ind |
|---|---|---|---|---|---|---|---|
| 0 | 4 | 65535 | Pref | New | Higher | 0 | off |
| 1 | 5 | 65535 | Pref | Same | Same | 1 | off |
| 2 | 6 | 65535 | Pref | Same | Same | 2 | off |
| 3 | 7 | 65535 | Pref | Same | Same | 3 | off |
| 4 | 11 | 65535 | Pref | Same | Same | 1 | off |
| 5 | 13 | 65535 | Pref | Same | Same | 1 | off |
| 6 | 15 | 65535 | Pref | Same | Same | 1 | off |
| 7 | 17 | 65535 | Pref | Same | Same | 1 | off |
| 8 | 19 | 65535 | Pref | Same | Same | 1 | off |
| 9 | 100 | 65535 | Pref | New | Same | 0 | off |
| 10 | 101 | 65535 | Pref | Same | Same | 1 | off |
| 11 | 102 | 65535 | Pref | Same | Same | 2 | off |
| 12 | 103 | 65535 | Pref | Same | Same | 3 | ON |

TABLES I and II show an example of a PRL. The PRL contains an Acquisition Table (TABLE I) and a System Table (TABLE II). The Acquisition Table contains records that list communication channels or frequencies in a priority contact order from top to bottom. For the Acquisition Table as shown, for example, a mobile unit would contact PCS CDMA Block B channels first, then Block A channels, then channels 283, 699, 384, and 777. If the mobile unit cannot contact these CDMA channels, the mobile unit would attempt contact with Cellular Analog System A frequencies. If no contact can be established with channels or frequencies listed in the PRL, the mobile unit will attempt to acquire a fixed communication system using procedures outside the PRL feature.

The PRL's System Table contains records having several fields. The "SID" field contains the System Identification number of preferred systems. The "NID" field is for a Network Identification, similar to SID entries. The "Neg/Pref" field indicates if the particular SID or SID/NID pair is preferred, or alternatively if it is "negative" and should not be contacted. The "Geo" field contains an indication of the SIDs geographic region. For example, record 0-8 SIDs are in the

same geographic region, record 9 shows that SID 100 is in a new geographic region, and record 10-12 SIDs are in the same geographic region as the record 9 SID. The "Priority" field operates similarly to the "Geo" field, but with respect to relative SID or SID/NID pair contact priorities. As shown, for example, SID 4 is higher priority than SID 5, and SID 5 is higher priority than SID 6. The "AcqIndex" field refers back to the Acquisition Table record number associated with a SID or SID/NID pair. Thus the "AcqIndex" field entry indicates the channel(s) or frequency(ies) associated with the particular SID or SID/NID pair. As shown, for example, SID number 4 (AcqIndex 0) is associated with PCS CDMA Block B channels (Acquisition Table record 0). Similarly, SID 7 (AcqIndex 3) is associated with Cellular Analog System A frequencies (Acquisition Table record 3). Finally, the "Roam Ind" field indicates a roaming indication display status on the mobile unit. Four roam indications are possible; "off", "on", and "flash" are the three typically used.

A typical mobile unit processor executes a system acquisition function to contact a fixed communication station based on PRL entries. While many variations are possible, the following description applies to a conventional system acquisition procedure.

To determine the order in which the mobile unit is to contact channels or frequencies, the system acquisition function builds a scan list. A mobile unit's system acquisition function typically maintains a "most recently used" list of channels or frequencies, and places this list at the beginning of the scan list. Then, the system acquisition function continues to build the scan list using the information in the PRL Acquisition Table. Once the scan list is built, the system acquisition function begins to search for base station pilot signals in the scan list order.

When the mobile unit encounters a pilot signal from a base station, the system acquisition function continues to operate and receives a SID from the base station over an associated synchronization channel. The acquisition function then compares the received SID to the SIDs in the PRL System Table. If the received SID matches a System Table SID that has the highest priority, the system acquisition function continues and establishes communication with the base station associated with the SID. However, if the received SID does not match a System Table SID, or if the received SID matches a System Table SID but higher priority SIDs exist in the table, the system acquisition function places the received SID in an "available list" and continues to search for a preferred SID. To speed acquisition, if the received SID is in the System Table but other SIDs have higher priority, the system acquisition function builds an abbreviated scan list of only those channels or frequencies associated with SIDs having higher priority. Thus the "AcqIndex" System Table fields point back to the Acquisition Table records so that the system acquisition function may build such an abbreviated list. After acquiring the communications system having the highest possible priority SID, the mobile unit registers with the contacted system.

Unfortunately, the system acquisition function's use of the PRL leads to a problem when the mobile unit is operating in the fringe of a base station's geographic coverage area or in other weak signal areas. If the mobile unit loses communications with a particular base station, i.e., a particular SID, but the base station's signals are still intermittently received, the system acquisition function will often continue to attempt access with the base station due to the PRL priorities as described above. Thus a continuous loop of establishing and breaking communication with a single base station occurs. When this establishing/breaking loop happens it effectively prevents the mobile unit from sending or

receiving calls. What is required, therefore, is a way to break the acquisition attempt loop and to force the system acquisition function to acquire a different base station.

Summary

In accordance with the present invention, a processor, such as may be contained in a wireless mobile communications unit, is configured to implement a process to limit the number of system access attempts for a communications system selected from a preferred roaming list (PRL). After a specified number of access failures, or other communication failures, the mobile unit selects another system identification from the PRL. The mobile unit continues this process until establishing a successful system access, receiving overhead messages in accordance with the TIA/EIA/IS-95A standard.

As the processor attempts access, it monitors for specific access failures. For example, the processor may monitor for idle fade expiration, sleep report reacquire failure, lost paging channel, maximum access probe failure, synchronization channel acquisition failure, and other acquisition failures. For each failure encountered before successful system access, the processor increments the counter by one and reattempts system access. After the counter reaches a specified value, the processor stops access attempts for the presently selected system identification and selects a new system identification from the PRL. The processor then attempts to acquire a new base station and access the new system. The processor repeats this procedure until establishing a successful system access.

Brief Description of the Drawings

FIG. 1 is a block diagram showing a typical mobile communications unit, base stations and associated mobile switching centers, and a computer.

FIG. 2 is a flow diagram outlining a process implemented by an embodiment of the present invention.

FIG. 3 is a flow diagram outlining a portion of a process implemented by an embodiment of the present invention in greater detail.

Detailed Description

This description refers to a "channel" or to "channels", which in particular refers to CDMA channels such as Personal Communication System (PCS) CDMA channels. However, those skilled in the art should understand that "channel" should be broadly construed and may mean, for example, other transmission qualities such as a frequency or range of frequencies. In addition, this description refers to instructions executed by a "processor", a term which also should be broadly construed to include any hardware device capable of executing machine instructions. For example, a processor may be a single integrated circuit, several interconnected integrated circuits, a mobile communications unit, or a computer.

FIG. 2 is a process flow diagram illustrating an embodiment of the invention. Embodiments of the process may be carried out by a wireless mobile communications system unit such as mobile unit 10 shown in FIG. 1.

In step 102 a processor contained within a wireless mobile unit detects the need to acquire a communications system and initiates a system acquisition function. In some embodiments the acquisition procedures conform to standard protocols for establishing a communication link with a base station and MSC, such as those contained in Telecommunications Industry Association/Electronics Industry Association Interim Standards

95/95A (TIA/EIA/IS-95/95A), which are incorporated herein by reference. However other embodiments may use non-standard protocols such as may be used in, for example, a proprietary communications system.

In step 104 the processor builds a scan list using information contained in a PRL stored in non-volatile memory 26 (FIG. 1). The scan list may include information such as most recently used channels, or may be abbreviated as described above.

In step 106 the processor refers to the scan list and begins to monitor for pilot signals associated with channels as prioritized in the scan list. If no pilot signal is detected for a particular channel, as shown by the "N" (no) branch in step 108, the processor returns to step 106, gets the next available scan list channel, and again monitors for a pilot signal.

Once the processor detects a pilot signal for a particular channel, the processor sets a counter to a selected value such as zero (0) as shown in step 110. The processor then continues the system acquisition function and monitors for failures as shown in step 112. Details regarding failure monitoring are described below in relation to FIG. 3.

In step 114 the processor determines if a communications failure has occurred during step 112. If no failure has occurred, the processor moves to step 116 and resets the counter. The counter is reset after the processor sends a successful registration attempt message to the communications system, e.g., a base station. In step 118, with system acquisition complete, the processor directs the mobile unit to enter an operating state such as active communication, idle, or sleep modes.

If the processor determines in step 114 that a communications failure has occurred in step 112, however, the processor executes step 118 and compares the counter value to a

fixed value N. In some embodiments the value assigned to N is three (3). Three is chosen because it represents a good compromise between communication delay which results from large values of N forcing many system acquisition loop repetitions, and normal communication losses such as travel in and around buildings, as determined during field testing. Other embodiments may use different values for N.

If the processor determines that the counter is less than N in step 118, the processor increments the counter by one in step 120. Then, the processor continues to implement the system acquisition function as shown by steps 122 and 112.

If the processor determines that the counter equals N in step 118, however, the processor stops attempting to acquire a system using the selected channel. Instead, the processor returns to step 106 and selects a new channel. The processor then continues as described above to contact, acquire, and register with a system using a newly selected channel.

FIG. 3 is a process flow diagram showing the failure checking of step 112 in more detail. As shown, the failure checking routine monitors for failures while the mobile communications unit attempts to access a communications system as described above. Failure monitoring is done in a continuous process, but FIG. 3 omits the loop for clarity. In this embodiment, five general failures are monitored. In other embodiments, more or fewer failures may be monitored, and failures other than those shown may be monitored.

In step 140 the processor checks if the idle fade has expired. That is, the mobile unit is in an idle state and experiences communication loss for a given time.

In step 142 the processor checks if a sleep report reacquire has failed. Similar to an idle fade timeout, if the mobile unit is in a sleep mode and fails to reestablish communication during periodic wake-ups (approximately every 1.3

seconds in some embodiments), the processor will consider this loss to be a failure.

In step 144 the processor checks if the mobile unit has lost the paging channel, and in step 146 the processor checks if a synchronization channel acquisition failure has occurred.

In step 148 the processor checks for other acquisition failures. One type of acquisition failure is known as a maximum access probe failure. As the mobile unit attempts to access a particular base station it sequentially increases transmission power up to a given limit. If the mobile unit reaches the prescribed transmission power limit and is still unable to contact the base station, the processor will record a maximum access probe failure. Other acquisition failures, such as failures during conventional acquisition protocols, are also monitored.

Referring again to FIG. 1, a computer 50 contains a memory 52 and is configured to accept removable data storage medium 54. Computer 50 may be a conventional personal computer, and storage medium 54 may be any conventional medium such as a diskette, removable disk drive, or compact disk. Memory 52 and storage medium 54 may be configured to contain instructions implementing the process in accordance with the present invention. As shown, computer 50 may be connected to connector 56 on mobile unit 10 via line 58. Thus a signal 60 that is configured to contain instructions in accordance with the present invention may be transferred from memory 52 or storage medium 54 to a location in mobile unit 10 such as program memory 26 or data memory 28. Other communications links between computer 50 and mobile unit 10 are possible. For example, mobile unit 10 may receive broadcast signal 60 through antenna 30.

While the present invention has been described in terms of particular embodiments, those skilled in the art will appreciate that many possible embodiments fall within the

spirit and scope of the invention. The present invention is therefore limited only by the claims that follow.

Claims

I claim:

1. A communications device comprising:
a processor;
a first memory coupled with the processor and containing instructions for the processor; and
a second memory coupled with the processor and containing a priority list of communications systems;
wherein while executing the instructions and sensing a condition indicating the possibility of communicating with a first communication system selected from the priority list, the processor:
(a) attempts communication with the first communications system;
(b) detects a communication failure with the first communications system; and
(c) after the communication failure, ceases to attempt communication with the first communications system and attempts communication with a second communications system selected from the priority list.

2. The device of claim 1 wherein the device is a portable radio transceiver.

3. The device of claim 1 wherein the device is a programmed electronic computer.

4. The device of claim 1 wherein the processor is an integrated circuit.

5. The device of claim 1 wherein the condition comprises receiving a pilot signal.

6. The device of claim 1 wherein the communication failure comprises an idle fade expiration.

7. The device of claim 1 wherein the communication failure comprises a sleep report reacquire failure.

8. The device of claim 1 wherein the communication failure comprises a lost paging channel.

9. The device of claim 1 wherein the communication failure comprises a maximum access probe failure.

10. The device of claim 1 wherein the communication failure comprises a synchronization channel failure.

11. The device of claim 1 wherein the communication failure comprises an access channel failure.

12. The device of claim 1 wherein the communications failure occurs after at least one earlier communications failure with the first communications system.

13. A communication system acquisition process, to occur while a processor can sense a condition indicating the possibility of communicating with a first communication system selected from a priority list of communications systems stored in a memory, the process comprising:

attempting communication with the first communications system;

detecting a communications failure with the first communications system; and

after the communication failure, ceasing to attempt communication with the first communications system and attempting communication with a second communications system selected from the priority list.

14. The process of claim 13 wherein the condition comprises receiving a pilot signal.

15. The process of claim 13 wherein the communication failure comprises an idle fade expiration.

16. The process of claim 13 wherein the communication failure comprises a sleep report reacquire failure.

17. The process of claim 13 wherein the communication failure comprises a lost paging channel.

18. The process of claim 13 wherein the communication failure comprises a maximum access probe failure.

19. The process of claim 13 wherein the communication failure comprises a synchronization channel failure.

20. The process of claim 13 wherein the communication failure comprises an access channel failure.

21. The process of claim 13 wherein the communications failure occurs after at least one earlier communications failure with the first communications system.

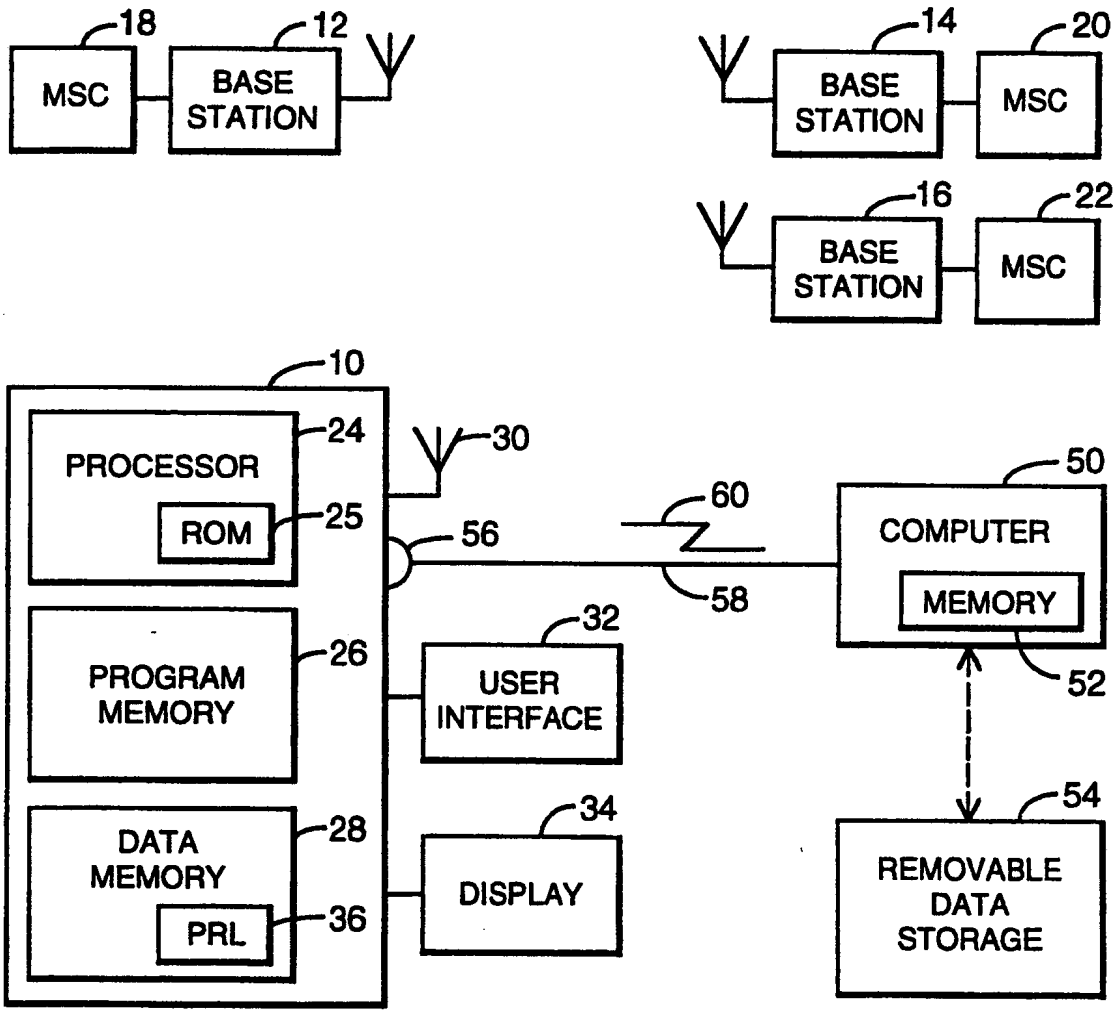
18
12
MSC
BASE STATION
14
20
BASE STATION
MSC
16
22
BASE STATION
MSC
10
PROCESSOR
24
ROM
25
30
60
56
50
COMPUTER
MEMORY
58
32
PROGRAM MEMORY
26
USER INTERFACE
52
DATA MEMORY
28
PRL
36
34
DISPLAY
54
REMOVABLE DATA STORAGE

FIG. 1

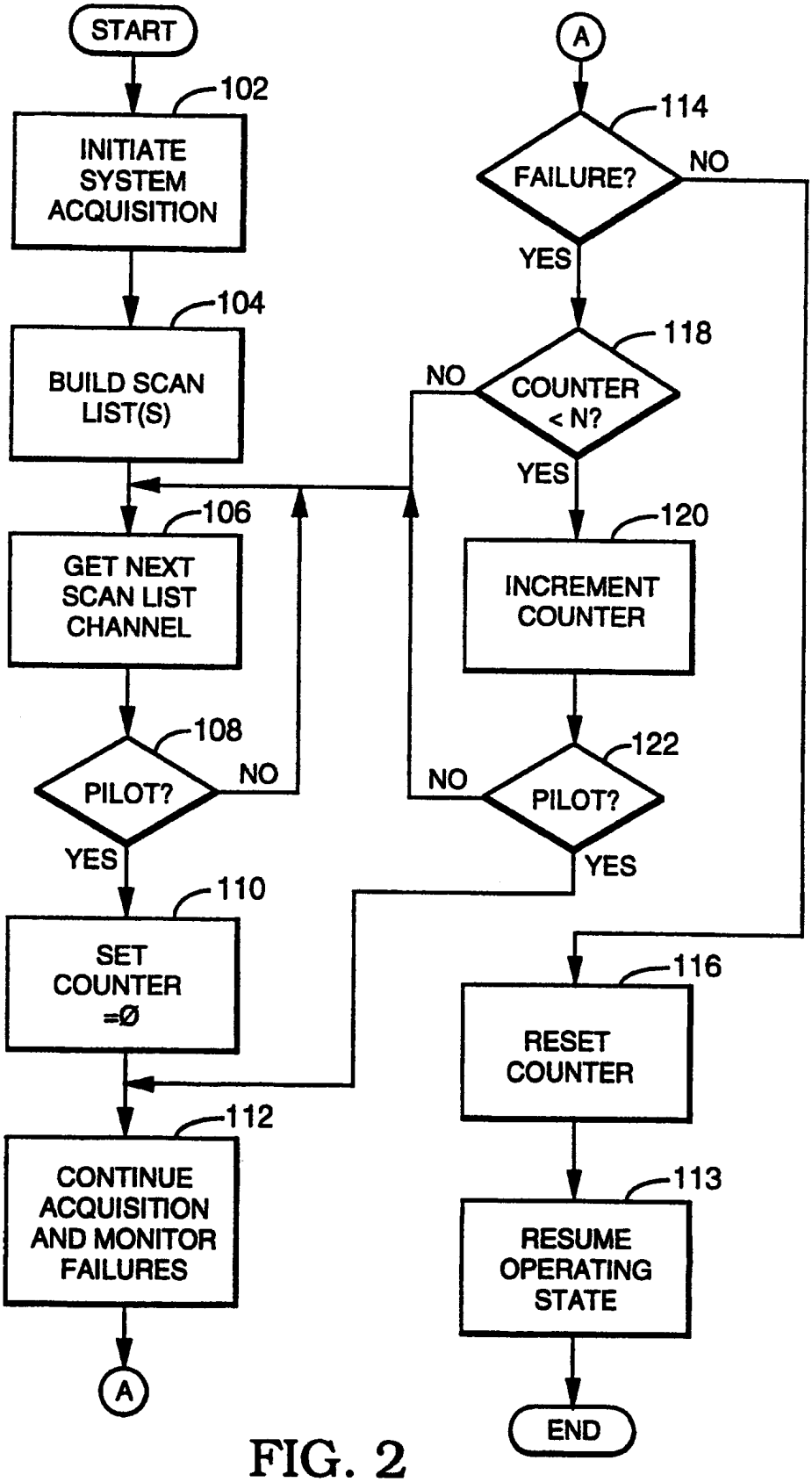
START
102
INITIATE SYSTEM ACQUISITION
104
BUILD SCAN LIST(S)
106
GET NEXT SCAN LIST CHANNEL
108
PILOT?
NO
YES
110
SET COUNTER =Ø
112
CONTINUE ACQUISITION AND MONITOR FAILURES
A
A
114
FAILURE?
NO
YES
118
COUNTER < N?
NO
YES
120
INCREMENT COUNTER
122
PILOT?
NO
YES
116
RESET COUNTER
113
RESUME OPERATING STATE
END

FIG. 2

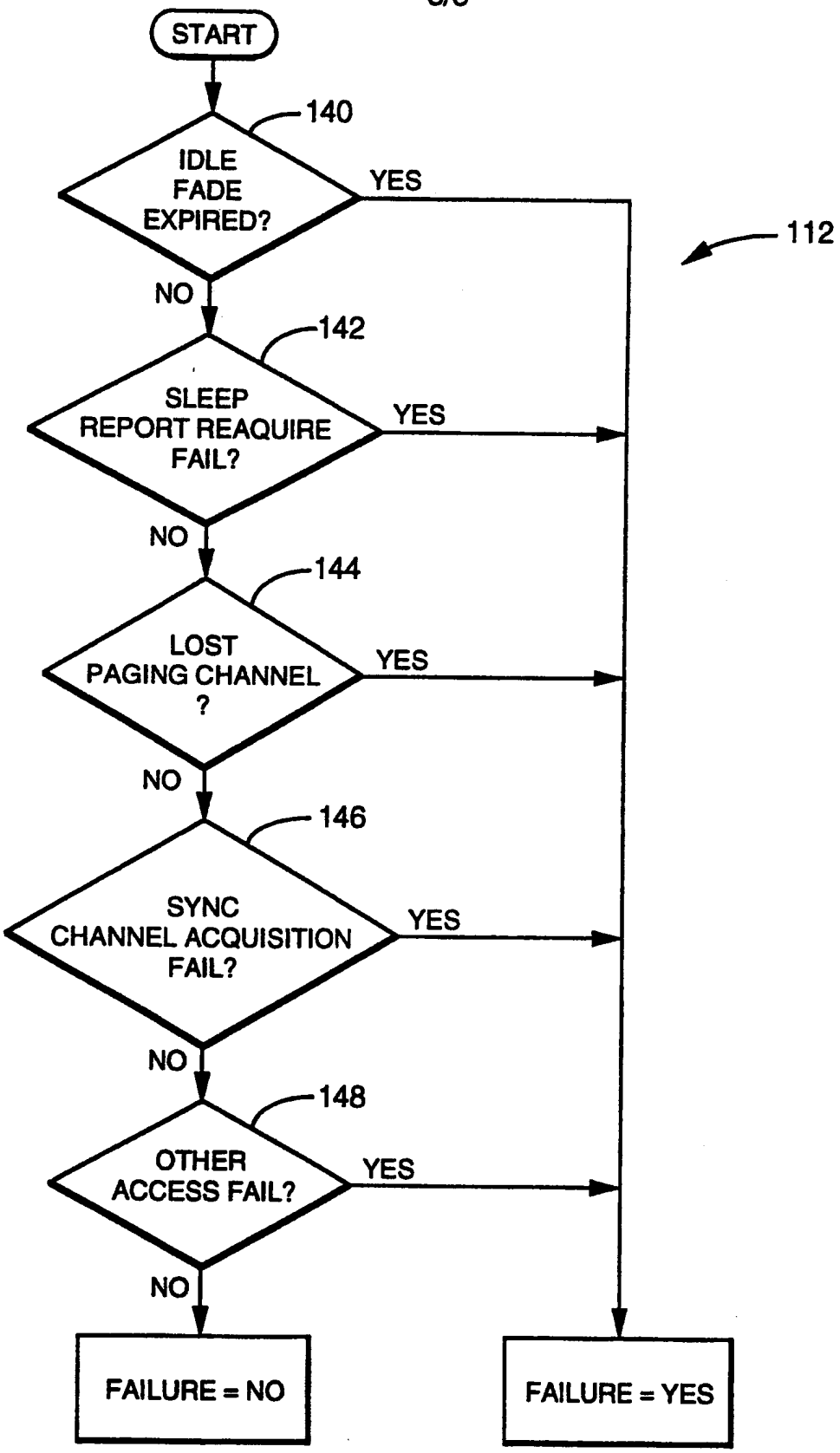
START
140
IDLE FADE EXPIRED?
YES
112
NO
142
SLEEP REPORT REAQUIRE FAIL?
YES
NO
144
LOST PAGING CHANNEL ?
YES
NO
146
SYNC CHANNEL ACQUISITION FAIL?
YES
NO
148
OTHER ACCESS FAIL?
YES
NO
FAILURE = NO
FAILURE = YES

FIG. 3

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/16612

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :H04M 11/00; A63B 67/00
US CL :455/550
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/550, 551, 552, 432, 434, 435, 436

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5,428,666 A (FYFE et al) 27 June 1995, col. 3, line 65 - col. 5, line 50; figures 1-2. | 1-5, 11-14, 20, 21 |
| X | US 5,903,832 A (SEPPANEN et al) 11 MAY 1999, col. 5, line 31-col. 7, line 49 | 1-5, 11-14, 20, 21 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
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